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STRETCHING APPARATUS

Field of the Invention

The present invention relates to an apparatus for stretching muscles, tendons, ligaments and other soft tissues of the human body and particularly although not exclusively for stretching muscles of the hip joint and lower limbs.

Background to the Invention

Human limb flexibility, including muscle extensibility and joint mobility is known to be of importance in the prior art in sport and general fitness for the avoidance of injury and improvement of performance as well as in clinical rehabilitation following injury.

The hip joint is of considerable importance regarding athletic activity. Abnormal function of the hip pre-disposes the subject to a variety of sports injuries. In the non-athletic population hip dysfunction may ultimately lead to arthritis and back pain. Stretching exercises are known to be used to improve hip mobility to reduce predisposition to injury or disorder. Hip stretching exercises are difficult to perform unaided, that is in the absence of a physiotherapist, due to the need to stabilize the pelvis, thus isolating the hip joint to ensure that movement takes place only at/around the hip joint whilst conducting the exercises and also due to the considerable forces required to overcome tightness in strong muscles and other soft tissues of the hip joint in performing the stretches.

A small number of prior art stretching apparatus are known including US 4,574,789, US 5,405,306, US 4,647,040, FR 2613238, US 5,449,336, US 5,261,865, US 4,819,936 and FR 2,357,236.

US 5,405,306, US 5,449,336 and US 5,261,865 all disclose stretching apparatus for stretching of human lower limbs. Each apparatus

consists of a frame provided to allow a subject to be positioned in a supine position, that is on their back. A material loop or cuff is provided for positioning over the foot or ankle of the subject wherein the cuff is connected to a cable. The cable is arranged over a system of pulleys to extend to a handle connected to one end of the cable. By pulling on the handle the subject can raise and lower one or both legs to perform a stretch. In US 5,405,306 the cable can be arranged through one of a plurality of pulley sets to enable both flexion and abduction stretches of the lower limbs. In US 5,449,336 and US 5,261,865 a belt is provided to encircle the subject's waist in order to stabilize the pelvis against the base platform of the apparatus.

Prior art apparatus of a type such as that disclosed in US 5,405,306 requires substantial variation of the setup configuration to perform more than one type of stretch. Limited abduction and adduction of the hip joint can be performed by pulling of cables to transfer a component of force to the coronal plane. This system is energy inefficient and introduces unwanted force components which act to stretch the limb in other planes of movement and which result in undesirable strain of the stretching muscles. The result is a mixing of stretches which limits the ability to controllably perform a desired stretch.

FR 2613238 and US 4,647,040 provide stretching apparatus arranged for abduction of the lower limbs. Leg supports are provided upon which the subject rests their legs. An actuating arm enables the subject to perform abduction stretches.

US 5,913,759 discloses apparatus for performing extension stretching of the thigh muscles wherein an arm member contacts the front muscles of the users thigh and a motor is provided to urge the arm

contacting the thigh downwardly thus stretching the thigh muscles on the front side of the leg.

FR 2357236 discloses apparatus for performing kinetic joint therapy wherein a moving panel hinges on a horizontal fixed panel. The moving panel provides a leg support and the fixed panel may be used to secure the upper body in position. This apparatus relies on the leg muscles of a subject or a second person to position the moving panels; it has no actuating means by which the subject can effect movement. Furthermore, it does not allow adduction or rotation stretches to be performed.

Prior art stretching apparatus provides for specific lower limb stretching exercises to be performed. The use of cable and pulley systems is disadvantageous for several reasons. Use of cable and pulley systems does not enable precise movement of the limb during stretch as the cable is flexible to pivot about the pulleys such that the limb being stretched cannot be maintained within a single desired plane of stretch. Further, where the subject is required to manually operate the application of tension to the cables by pulling on the cable ends the tension applied to the stretch cannot be maintained uniform. This also results in the fatigue of the subject through application of tension to the cables which results in inability to maintain the limb in the stretched position.

When considering hip stretching exercises no single prior art apparatus provides for controlled stretching of the hip joint in all six anatomical directions. Where cable systems are used the prior art apparatus are required to be adjusted by repositioning or reattachment of the cable pulley system between different stretches. Use of straps or cuffs attached to the ankles results in uncontrolled stretching and use of the cable system has a result that the lower limb being stretched is subject to undesirable compressive or tensile forces along its length.

In order to perform controlled stretching of single lower limbs it is necessary to position the resting lower limb in a substantially fixed resting position. The prior art apparatus does not provide means for positioning the resting limb in a predetermined resting position which assists stretching of the stretching limb.

It is also known in the prior art that during flexion stretching the thigh of the resting leg will tend to rise as the stretching leg reaches maximum tension. This is unwanted as the subject's pelvis is tilted backwards as a result which reduces the effectiveness of the stretch.

Isokinetic testing apparatus, such as the Multi-Joint System 3 apparatus manufactured by Biodex Medical Systems Inc. New York, USA are also known in the prior art. Such isokinetic testing apparatus provide means for measuring muscle strength by application of a resistive force to a limb against which the subject pushes. These machines are known in the prior art for use in monitoring muscle strength and are useful in monitoring a subject's recovery from injury. In the prior art, apparatus for improving and/or monitoring muscle strength do not provide for stretching of the same muscles in a controlled manner.

Summary of the Invention

Apparatus for movement of the human lower limbs passively in specified pre-determined anatomical directions in order to increase or maintain a range of motion (ROM) of the hip joint is provided. A stretching force is applied in a controlled manner to stretch soft tissue structures, particularly the muscles that cross, or extend to/from the hip joint. A means of measuring the angle moved by the cradle supporting each limb is provided to enable the apparatus to be used for orthopaedic assessment and monitoring. A clamping means is provided to position

and hold the subject's pelvis to isolate the hip joint during stretching. Controlled positioning and stablisation of the lower limbs allows the subject to perform appropriate stretching regimes either unassisted or as directed by a therapist.

The stretching apparatus comprises two limb cradles, each arranged to fit under a subject's leg to support the leg. Each cradle is hinged at the hip and knee joints and is fitted with straps to secure the leg above and below the knee (preferably above the ankle). Each cradle is fully adjustable in terms of cradle length and width between the cradle movement means to accommodate for a wide variety of leg length and pelvic dimensions. The apparatus is therefore capable of fitting and supporting adults and juniors through a wide range of dimensions.

Each cradle connects to a cradle movement means having two pivots each defining an axis of rotation and providing for movement of the cradle through two planes of movement transverse to each other, and preferably orthogonal. The movement means may be controlled by a user to actuate movement of the cradle. A handle is provided for manual operation, but optionally movement of each cradle may be powered by an electric motor or may be servo assisted.

By providing two cradles the position of both resting leg and stretching leg can be carefully controlled. It is advantageous to fix the resting leg and pelvis of the subject during stretch of the stretching leg as this allows for quantitative comparisons of the relative degree and extent of stretch between the two legs. By providing a means to lock each cradle in a neutral position of 0° hip flexion and by providing straps to maintain the leg in this position, the tendency of the resting leg to rise during flexion stretching of the contralateral leg can be eliminated.

According to a first aspect of the present invention there is provided a stretching apparatus for use in stretching the lower limbs of a human subject comprising:

at least one cradle configured to support a leg, or part thereof, of said subject, said cradle moveable between a non-stretching position and a stretching position; and

at least one cradle movement means operable to move said cradle between said non-stretching and stretching positions,

wherein said cradle movement means comprises:

first movement means configured to move said cradle through a first plane of movement; and

second movement means configured to rotate said cradle through a second plane of movement transverse to said first plane of movement

According to a second aspect of the present invention there is provided a stretching apparatus for use in stretching the lower limbs of a human subject comprising:

at least one cradle configured to support a leg, or part thereof, of said subject, said cradle moveable between a non-stretching position and a stretching position, in use said cradle thereby positioning said leg, or part thereof, in said non-stretching and stretching positions respectively; and

at least one cradle movement means operable to move said cradle between said non-stretching and stretching positions, in use said cradle

movement means thereby moving said leg, or part thereof, between said non-stretching and stretching positions,

wherein said cradle movement means comprises:

first movement means configured to move said cradle through a first plane of movement for performing a first set of stretches; and

second movement means configured to rotate said cradle through a second plane of movement transverse to said first plane of movement for performing a second set of stretches.

According to a third aspect of the present invention there is provided a stretching apparatus for use in stretching the lower limbs of a human subject comprising:

a support table configured to support said subject's back and upper body in supine position; and

at least one cradle extending from one end of said table, said cradle configured to support a leg, or part thereof, of said subject, said cradle moveable between a non-stretching position and a stretching position; and

at least one cradle movement means operable by said subject from said supine position to move said cradle between said non-stretching and stretching positions,

wherein said cradle movement means comprises:

first movement means configured to move said cradle through a first plane of movement; and

second movement means configured to rotate said cradle through a second plane of movement transverse to said first plane of movement.

According to a fourth aspect of the present invention there is provided a stretching apparatus for use in performing controlled stretching of the muscles and soft tissues associated with the human hip joint, comprising:

two leg supports each for use in positioning a subject's leg during stretching, each leg support moveable between a stretching and non-stretching position and connected to:

a leg support movement means, each said leg support movement means having first and second pivots forming first and second axes of rotation, said leg support movement means operable to independently move said connected leg support through corresponding first and second planes of movement,

wherein movement in said first plane causes a movement of said support in a sagittal plane with respect to a human subject and movement in said second plane causes a rotation of each portion of said support in a coronal plane with respect to a human subject.

According to a fifth aspect of the present invention there is provided a stretching apparatus for use in performing abduction and/or adduction stretching of a human subject's thigh adductor and/or abductor muscles respectively, comprising:

at least one cradle configured to support a leg, or part thereof, of said subject such that said leg is held substantially in extended position, said cradle rotatable through a plane of movement; and

at least one cradle movement means operable to rotate said cradle about an axis of rotation and through said plane of movement so as to move said leg across and/or away from a midline of a subject's body to perform adduction and/or abduction stretches of the subject's leg respectively.

According to a sixth aspect of the present invention there is provided a stretching apparatus for use in performing medial or lateral rotation stretching of a human subject's thigh lateral rotator or medial rotator muscles respectively, comprising:

at least one cradle configured to support a leg, or part thereof, in a position such that the thigh of the supported leg is substantially orthogonal to the subject's upper body, said cradle rotatable about an axis of rotation so as to move a portion of said supported leg in a direction across or away from a midline of the subject's body to perform lateral rotation or medial rotation stretches respectively; and

at least one cradle movement means operable to rotate said cradle about said axis of rotation.

Brief Description of the Drawings

For a better understanding of the invention and to show how the same may be carried into effect, there will now be described by way of example only, specific embodiments, methods and processes according to the present invention with reference to the accompanying drawings in which:

Fig. 1A to E illustrates diagrammatically flexion, medial and lateral rotation, adduction and abduction stretching of a subject's leg and the associated rotational movement of the hip joint;

Fig. 2 illustrates diagrammatically extension stretch of a leg about the hip joint;

Fig. 3 illustrates in-use positioning of a subject on the stretching apparatus of the present invention;

Fig. 4 illustrates diagrammatically the location of a pelvic clamp at the pelvis of the subject during use of the stretching apparatus of the present invention to prevent lateral tilting of the pelvis and to isolate the hip joint for performing stretching exercises;

Fig. 5 illustrates a first embodiment of the stretching apparatus of the present invention in external perspective view;

Fig. 6 illustrates in external perspective view the limb cradles and chassis of the stretching apparatus in accordance with a first embodiment of the present invention;

Fig. 7A illustrates a side view of the right hand limb cradle and chassis of the stretching apparatus in accordance with the first embodiment of the present invention and illustrating the positioning of the cradle movement means;

Fig. 7B illustrates an end view of the right hand limb cradle in accordance with the first embodiment of the stretching apparatus of the present invention;

Fig. 8 illustrates a plan view of a right hand limb cradle in accordance with the first embodiment of the stretching apparatus and further illustrating positioning of the right hand cradle movement means;

Fig. 9 illustrates in external perspective view the limb cradle movement means;

Fig. 10A illustrates a front view of one of the cradle movement means and Fig. 10B illustrates a cross-section C-C (see Fig. 12B) through the same;

Fig. 11A illustrates a view on the line A-A of Fig. 10A;

Fig. 11B illustrates an opposing side view to Fig. 11A of the cradle movement means;

Fig. 12A illustrates a plan view of the right hand limb cradle movement means;

Fig. 12B illustrates a cross-section through the line B-B of Fig. 10B;

Fig. 13A illustrates the cradle movement means and cradle second section in external perspective view in accordance with a second embodiment of the present invention;

Fig. 13B illustrates a plan view of the cradle movement means and cradle second section in accordance with the second embodiment of the present invention.

Fig. 14A illustrates an elevation view of the right hand limb cradle and chassis of the stretching apparatus in accordance with a fourth embodiment of the present invention.

Fig. 14B illustrates a plan view of the support surface in a fourth embodiment of the present invention.

Fig. 15A illustrates an elevation view of the right hand limb cradle and chassis of the stretching apparatus in accordance with a fifth embodiment of the present invention.

Fig. 15B illustrates a plan view of the support bar in a fifth embodiment of the present invention.

Fig. 16A illustrates an elevation view of the right hand limb cradle and chassis of the stretching apparatus in accordance with a sixth embodiment of the present invention.

Fig. 16B illustrates a plan view of the support surface of the sixth specific embodiment of the present invention.

Detailed Description of the Best Mode for Carrying Out the Invention

There will now be described by way of example the best mode contemplated by the inventors for carrying out the invention. In the following description numerous specific details are set forth in order to provide a thorough understanding of the present invention. It will be apparent however, to one skilled in the art, that the present invention may be practiced without limitation to these specific details. In other instances, well known methods and structures have not been described in detail so as not to unnecessarily obscure the present invention.

In this specification the term cradle relates to a support, cuff, collar, stirrup or other support means configured to support a human subject's leg, or part thereof, in a selected position.

Referring to Fig. 1 herein, Fig. 1A illustrates diagrammatically a human subject in the supine position and illustrating a representation of the subject's hip joint 101 and knee joint 102 of each lower limb. Figs. 1B to E illustrate the stretches which can be performed by using the stretching apparatus of the present invention.

Fig. 1B illustrates flexion of the subject's left leg wherein the subject's leg is raised by movement of the leg about the hip joint in the sagittal plane of motion. In performing this stretch the stretching leg is lifted upwards from the resting position to a maximum displacement of approximately 120° from the resting supine position wherein the limb is in-line with the main length of the subject's body. Flexion stretches the hamstrings at the back of the subject's thigh and in particular the Semimembranosus, Semitendinosus, Biceps femoris muscles as well as partially stretching the Gluteus maximus.

Fig. 1C illustrates the subject's left leg raised from the resting position such that the knee is bent at approximately 90° to the thigh which is maintained transverse and generally orthogonal to the subject's main body length. With the leg in this position where the hip and knee are both bent at approximately 90° planar movement of the leg between the knee and foot enables rotational stretching of the hip joint. In particular, planar movement away from the subject's body is known as medial rotation resulting in stretching of the lateral rotator muscles, in particular of the Piriformis, Gemellus superior, Gemellus inferior, Obturator internus, Obturator externus, Quadratus femoris. Planar movement of the foot or

calf towards and across the midline of the subject's body is known as lateral rotation resulting in stretching of the medial rotator muscles, in particular the Gluteus medius, Gluteus minimus and Tensor fasciae latae.

Fig. 1D diagrammatically illustrates adduction stretching wherein the subject's left limb is maintained outstretched in the supine position and the leg is moved through the coronal plane (also known as the frontal plane) about the hip joint to move the leg towards and across the midline of the subject's body so as to stretch the thigh abductors, in particular the Gluteus medius, Gluteus minimus, Tensor fasciae latae and the soft tissue structure of the Iliotibial band. During adduction stretching the resting limb is preferably placed in a rest position which avoids obstruction of the adduction stretch of the stretching limb. In Fig. 1D the rest position is illustrated with the leg raised and bent.

Fig. 1E illustrates abduction stretching wherein the subject's left leg is moved about the hip joint by rotation through the coronal plane of movement, the outstretched straight limb being moved away from the body to stretch the thigh adductors, in particular the Adductor brevis, Adductor longus, Adductor magnus, Gracilis and Pectineus muscles.

Abduction and adduction are movements about a sagittal axis. Abduction is movement away from a mid-sagittal plane in a lateral direction away from a midline of a subject's body which extends generally through the human torso and defining an approximate anatomical line of symmetry between the left and right hand sides of the body. Leg movements during abduction and adduction are therefore away from and across this midline respectively.

Referring to Fig. 2 herein, a subject is illustrated in position for performing extension stretching. The subject's left resting (contralateral)

leg is held in a leg support cradle in a raised and bent resting position of approximately 120° hip flexion and 90° knee flexion which has the effect of tilting the subject's pelvis posteriorly. For a subject whose extension stretching is less than optimal the stretching thigh (right thigh in Fig. 2) will rise above the horizontal. The stretching leg is retained in the support cradle by straps and the cradle is released to move under gravity towards the horizontal position. This enables extension stretching to be performed wherein the stretching leg moves through a first plane of movement around the hip joint to stretch the subject's hip flexors at the front of the subject's thigh, in particular the Psoas major, Iliacus, Sartorius, Tensor fasciae latae. The stretching leg is maintained and supported by the cradle at either 90° knee flexion, which stretches the Rectus femoris in addition to the hip flexors, or 0° knee flexion (the dashed outline of the subject's lower leg) which stretches the Iliotibial band in addition to the hip flexors.

The stretches illustrated in Figs. 1 and 2 and described above enable selective stretching of the hip joint through all six anatomical directions, i.e. flexion and extension, abduction and adduction and medial and lateral rotation. The stretching apparatus of the present invention enables the subject to perform each of these stretches in an independent and mutually exclusive manner which enables the user to carefully control the extent of stretch and to monitor relative progress of the subject.

Fig. 3 illustrates apparatus according to a first embodiment of the present invention in use by a subject. The subject 301 is illustrated in resting supine position. The subject's head and upper body as far as the hips is supported on an examination table 302 typically comprising a padded couch to support the subject's back. The examination table is raised from a ground surface by one or a plurality of leg supports 303 which raise the examination table approximately 60 – 80 cm from the

ground surface. The leg supports 303 are optionally adjustable to accommodate subject's of varying size. Two cradles 306, each configured to support one of the subject's legs extend from one end of the examination table. In supine position the subject's upper body and head are supported by the padded couch 302 and the subject's legs are located in cradles 306 and, in resting position, each cradle 306 extends in-line with the examination table so that the user is in a relaxed supine resting position. A pelvic clamp 305 forming a vice-like restraint to stabilize the pelvis laterally by gripping the subject's ilium on either side is provided. The clamp 305 is attached to the examination table in the region of the end of the examination table adjacent cradles 306. The pelvic clamp comprises two clamping members arranged on opposite sides of the examination table and connected by a screw member. Rotation of a handle at one end of the connecting screw member urges the clamping members 304 together to grip the subject at the pelvis. Once clamped, the subject's pelvis is prevented from tilting laterally during stretching such that the hip joints and lower limb joints and muscles are effectively isolated from the upper body movements during stretching. Optionally, a belt may be further provided to locate over the subject's waist to further facilitate isolation of the hip joint from the upper body during stretching. A cradle movement means is provided at the connection between cradles 306 and table 302 such that an axis of the cradle movement means is in line with the main axis extending through the subject's hip joints. The cradle movement means comprise a handle on the exterior facing side of the apparatus which is within reach of the users arms (not shown) when in supine position such that the subject can control movement of the cradles 306 to perform the required stretching exercises.

Referring to Fig. 4 herein an outline of the bone structure of the subject's pelvis and hip joint when positioned on the apparatus of the present invention in accordance with Fig. 3 is illustrated. Clamping

members 402, 403 having a shape and configuration designed to engage at and grip the iliac crests 401 of the subject's pelvis are provided. Fig. 4 illustrates two designs of clamping member, a first design 402 having a C-shaped cross-section and a second design 403 having a V-shaped cross-section. A screw member 404 is provided with an actuating arm to urge the clamping members 402, 403 together to grip the iliac crests of the subject's pelvis in a vice-like manner. Each clamping member 402, 403 is approximately 10cm in width, sufficient to encapsulate the profile of the subject's iliac crests. A belt 407 is optionally further drawn across the subject's waist to further prevent rotation of the pelvis during stretching. The subject's hip joints 405 are thus isolated from the upper body during stretching. The outer edge of the cradles 406 are illustrated adjacent the hip joints.

The pelvic clamp 305 is optionally configured to tilt forwards and backwards through predetermined positions allowing the subject's pelvis to be positioned at a desired degree of tilt during stretching. The clamping members are optionally configured for automatic adjustment to grip the subject's pelvis. Pressure sensing means are optionally provided to sense contact of the clamping members 402, 403 with the subject's pelvis. The sensing means feedback control signals to a processor which operates to automatically move the clamping members 402, 403 to maintain a selected clamp pressure at the pelvis.

Fig. 5 illustrates an external perspective view of a first embodiment of the stretching apparatus of the present invention. Two cradles are illustrated for supporting the subject's lower limbs, particularly the subject legs and feet. Each cradle is made up of three sections. A first section 501 is provided to support the subject's calf, ankle and foot, a second section 502 is provided to support the subject's lower thigh and a third section 503 supports the subject's upper thigh and buttocks. Each cradle

is formed in the shape of a channel profiled to correspond to the general profile of the human leg. Mirror image channels are provided on corresponding cradles formed on either side of the apparatus to correspond to the right and left leg profiles. First and second cradle sections 501, 502 are connected by a hinge 507 permitting movement of the first cradle section 501 about the hinge to accommodate bent-knee leg positions. A connecting bar and hinge 508 forms a locking means enabling each cradle to be locked in a substantially linear or angled position. Third cradle section 503 is mechanically fastened to the cradle movement means 504. Two cradle movement means 504 are provided, each providing separate means to independently operate movement of the attached cradle. A frame 505 connects the two cradle movement means 504 and locates each cradle movement means in opposing orientation at one end of the respective third cradle section 503. Each cradle movement means 504 further comprises a handle portion 506 arranged such that the subject occupying the stretching apparatus can grasp each handle portion 506 with their respective hand to operate movement of the cradles to perform a stretch. Each cradle movement means 504 is mounted on a respective third cradle section 503 by means of a plate and fastening means e.g. screw or bolt fastening means 505. The plate fastening cradle movement means 504 to third cradle section 503 comprises slots enabling the height of the cradle movement means 504 to be adjusted such that an axis through the subject's hips is in-line with the axis of rotation of the cradle movement means 504 through a first plane of movement.

Fig. 6 illustrates an external perspective view of the two cradles of the stretching apparatus in the absence of the cradle movement means and connecting frame. Each cradle formed by first, second and third cradle sections 501, 502, 503 forms a limb support and is made of either molded plastics material or preformed metal sheet lined with padded material so as to provide a comfortable leg support. First cradle section

501 configured to support the lower leg is connected to second cradle section 502 at hinge 507 which allow for rotation of the first cradle section about hinge 507 such that non-linear leg positions can be accommodated and supported by each cradle. First and second cradle sections 501, 502 are further connected by a locking means 508 in the form of a guide bar extending between the side portions of the two cradle sections. Guide bar 508 is configured to releasably lock first and second cradle sections 501, 502 in linear position. Unlocking the locking means 508 provides for relative movement of the first and second cradle sections 501, 502 so that the subject may position one or both legs in a bent arrangement. The locking means can be re-engaged once in bent configuration so as to support one or both legs in the bent position. First and second cradle sections 501, 502 are formed such that, in the linear arrangement illustrated in Fig. 6, a gap 605 is provided between the base portion supporting the subject's legs, this gap 605 providing for relative transverse movement of the first and second cradle section 501, 502.

Further referring to Fig. 6 herein, each second cradle section 502 is adjustably mounted at the third cradle section 503. Each third cradle section 503 comprises a base portion and walls defining a channel, each wall portion comprising an aperture having a plurality of slotted recesses. A fastening hinge member 604 extends through aperture 603 and a wall portion of the second cradle section 502 to securely connect second and third cradle sections 502, 503. Fastening hinge means 604 is moveable through aperture 603 to engage at a selected slotted recess thereby providing an adjustment mechanism. Adjustment of the position of the second cradle section 502 at the third cradle section 503 provides a length adjustment mechanism for the stretching apparatus to accommodate a variation in subject lower limb size which enables the hip joint to be located adjacent to the cradle movement means of the apparatus and the knee joint to be located adjacent to hinge 507. Plate member 606 having slots

601 is provided on the external wall portions of the third cradle section 503 for attachment to the cradle movement means. Each third cradle section 503 has a ribbed external structure 602 providing support and strength to the stretching apparatus.

Referring to Fig. 7A herein there is illustrated an engineering drawing showing a side view of the right hand limb cradle. The lower leg support 501 is illustrated to be connected to the upper leg support 502 by a pivot 507 corresponding to the position of the subject's knee joint during use. Locking means 508 is formed by a latch plate which allows the upper and lower leg supports 502, 501 to be fixed in-line or at right angles, although any suitable locking means such as a spring loaded plunger may be used. Aperture 603 in the third cradle section provides 110mm length of adjustment for variations in the subject's upper leg length, illustrated by arrow 701. The variable position of the upper leg support 502 through adjustment of the fastener 604 through the slotted aperture 603 is illustrated by arrow 705 and the dashed outline of the upper leg support 502 in the adjusted position. The position of the cradle movement means 504 is superimposed on the third cradle section 503.

Fig. 7B illustrates an end view of the right hand limb cradle of the stretching apparatus with the control movement means 504 and frame 505 superimposed and illustrated by dashed lines. The position of the centre line of the hip and knee joints of the subject during use are illustrated by dashed line 703 and the position of the centre line of the right hip joint of the subject during use is illustrated by dashed line 702. The position of the centre line of the subject's body during use of the stretching apparatus is illustrated by dashed line 704.

Fig. 8 illustrates a plan view of the right hand limb cradle of the stretching apparatus. Each cradle section 501, 502, 503 comprises a

base portion and wall portions forming a channel and is manufactured from pressed aluminum powder coated and lined internally with a padded material. The subject's leg is retained in the limb cradle through the use of straps attached to the first and second cradle sections 501, 502. These straps (not shown) may comprise buckled straps or Velcro ®• straps extending from opposite wall portions of the cradle section and over a leg housed therein. The centre line of the subject's body 802 is illustrated. Further, the right hand side cradle movement means 504 is superimposed and illustrated by way of dashed lines.

Fig. 9 illustrates an external perspective view of the right and left hand side cradle movement means and connecting frame 505. Each cradle movement means comprises a base plate 901 arranged to form an arm for transfer of rotational movement about bearing 906. Each limb cradle is fastened through plate member 606 to a cradle movement means. An axle member 902 projects through plate 606 to operate raising and lowering of the cradle. Movement of axle member 902 is thus communicated directly to the respective cradle. Each cradle movement means 504 further comprises a handle 506 and first bearing 904. Handle 506 is moveable through a first vertical plane of movement and second transverse plane of movement indicated by arrows 912. The handle 506 is optionally specifically shaped, e.g. L-shaped, to enable ease of use in movement through the two planes of movement. In use, the subject manually pulls handle portion 506 or pushes handle portion 506 to move the handle portion through a first plane of movement. This causes movement of bearing 904 in one of the directions indicated by arrow 913. This movement is transferred to axle member 902 as a rotation of the axle member which is then transferred to the connected limb cradle to raise or lower the entire limb cradle accordingly. Cradle movement means 504 comprises a locking ratchet mechanism (not shown) which is coordinated with handle 506 such that a raised or lowered limb cradle position can be

maintained in locked position by activating the locking ratchet. The ratchet may further co-operate with a damping mechanism 903 such that on release of the ratchet lock the respective cradle is lowered under control of the damping mechanism 903 such that the limb housed in the cradle is lowered slowly. Alternatively, a switch (not shown) may be provided to reverse the direction of movement that the locking ratchet mechanism controls, such that by pushing the handle portion 506 the subject can exert a substantially downward force for extension stretches.

Further referring to Fig. 9 herein, when the handle portion 506 is moved in a plane transverse to the first plane of movement, i.e. in the left or right direction, the supporting plate and cradle movement means and attached cradle is moved about a second bearing member 906. This causes rotation according to arrow 914 about the axis of second bearing member 906 with the result that the attached cradle is moved in a direction either across the midline of the subject's body or away from the midline of the subject's body. Handle portion 506 and first bearing member 904 are mounted on a support column 905 connecting with the base plate 901 and second bearing set 906. A scale 910 is provided on the support column to indicate the height adjustment of the control movement means from the base plate 901. Control knob 915 located on the underside of the base plate and in-line with column 905 provides, through a rotation of knob 915, for adjustment of the height of the cradle movement means 904. Before commencing use of the apparatus for stretching the subject is directed to adjust the height of each cradle movement means such that the axle member 902 is substantially in line with the main axis through the subject's hip joints. This is desired for optimal stretching performance.

Further referring to Fig. 9 herein, frame member 505 forms a housing to support both cradle movement means. Each cradle movement means is located in a slotted aperture formed in the frame member 505. A

supporting column extends through aperture 505 and is locked in position by a control knob 508 rotatable to fix the supporting column in position. A ratchet mechanism 911 is further provided at the base of each support column extending through frame member 505 to control the rotational movement of the cradle movement means about second bearing set 906 and to enable the apparatus to be maintained in the stretching position until released by the subject wherein the return path of the bearing is optionally damped to prevent sudden movement upon release of the stretch. Through use of control knobs 908 the width of the control movement means is adjusted and monitored via scale 909. The subject is directed prior to use to adjust the width of the two cradle movement means to fit closely the subject's particular subject width between their hips.

Each cradle movement means thus provides means to move the respective attached cradle in a first plane of movement wherein the cradle is raised or lowered and the hip joint is moved to a position of flexion or extension with a maximum hip flexion of up to 120°. Each control movement means is also operable to rotate about second bearing set 906 thus moving the respective cradle in a second plane of movement transverse to the first plane of movement and generally at right angles (orthogonal) to the first plane of movement. With the subject's leg in a linear position, the non-stretching leg is raised to a bent position and abduction up to 60° and adduction up to 45° can be performed by the user pushing the handle portion 506 to rotate around bearing set 906 either towards the midline of the subject's body or away from the midline of the subject's body. With the stretching leg in an upright bent position similar rotations will result in medial rotation up to 45° and lateral rotation up to 60°. As a result movement in all six anatomical directions about the hip joint can be performed using the apparatus by movement of the handle and the attached cradle through two planes of movement. These ranges of movement are the likely maximum ranges of movement of a human

subject, although it is envisaged that the apparatus may extend beyond these ranges of movement.

Each bearing set has an associated locking ratchet allowing the apparatus and subject's leg contained within the cradle to be maintained in a stretched position without the user having to hold the leg or cradle in that position. The flexion ratchet is damped such that upon release of the locking ratchet return to a resting position occurs slowly without damage to the user's muscles or soft tissue or cradle. Means to adjust both height of the cradle movement means and width between the two opposing cradle movement means makes the apparatus suitable for adults of both sexes and subjects of various heights, width and general dimensions.

Fig. 10A illustrates a side view of one of the cradle movement means from the far end of the first cradle section. The right hand leg cradle sections are shown by dashed lines and a right hand side cradle movement means is illustrated showing the intersection of axle member 902 with the third cradle section. Calibrated scale 910 is provided to monitor vertical adjustment of the cradle movement means. Vertical adjustment is performed by operation of the control knob 915. A second calibrated scale 909 is further provided on frame 505 to monitor width adjustment of the right and left hand side cradle movement mechanisms. The second calibrated scale 909 provides for 18.5mm horizontal adjustment at each side of the cradle movement means. Rotation through the second plane of movement about the second bearing set operates through ratchet mechanism 911 providing 4° increments and providing a plurality of positions at which the rotation may be locked. A retaining clamp 1001 retains the ratchet in position. Arrow 1002 indicates the preferred distance between the hip joint and buttock of the subject when correctly positioned in the cradle.

Referring to Fig. 10B herein a cross-section through the line C-C (refer to Fig. 12B) is illustrated. Movement of axle member 902 occurs about a first rotational axis extending through the centre line of the right and left hip joints 1003. Angular contact ball bearings 1004 providing radial and axial thrust are provided to form the first bearing set for rotational movement through a first plane of movement in performing flexion and extension stretches. The control knob 915 has a screw thread providing 30mm vertical adjustment. A spring loaded plunger is moveable between first and second positions in a slotted portion 1006 in the underside of base member 901. To position the right and left hand side cradle movement means at appropriate width to suit a particular subject each spring loaded plunger 1005 is moved downwardly away from the underside of base member 901 and the base member is slid to an appropriate position at which the spring loaded plunger 1005 is re-engaged in the slot 1006. This provides a manual push/pull movement to provide the maximum of 18.5mm of horizontal adjustment on each side of the apparatus.

Fig. 11A illustrates a view of the right hand side cradle means on the line A-A (see Fig. 10A).

Fig. 11B illustrates the right hand side cradle movement means of Fig. 11A illustrating a side view from the exterior of the apparatus. The positioning of the plurality of gears within the cradle movement means for transfer of movement of the handle 506 through a first plane of movement to cause rotational movement of the axle member 902 is illustrated. The first input gear 1101 driven by pushing or pulling of the handle by the subject in a first plane of movement drives a second transfer gear 1102 to rotate a third output gear 1103 connected to the axle member 902. The manually operated gear system is configured to enable the subject to generate sufficient force, by use of the subject's arm strength, to move a

leg, overcoming tension in the tissues to perform the stretch. A rotary damper 1104 is further provided to allow controlled descent of the subject's leg and cradle from an elevated position. The handle 506 and gear mechanism further incorporates a ratchet providing for controlled step movement and locking of the respective attached cradle at 4° increments. This provides a coarse control enabling gross movement to position the limb at the current maximum ROM of the subject.

Fig. 12A illustrates a plan view of the right hand side cradle movement means illustrating the positioning of the base member 901 on the frame 505. Clamping screw 908 provides for locking and unlocking of the base member 901 in a desired position and the slot 1201 formed in the frame member 505 provides for sliding movement of the second bearing set 906 to adjust the width between the right hand side and left hand side cradle movement means.

Fig. 12B illustrates a cross-section through the line B-B (see Fig. 10B) illustrating the angular contact ball bearings 1004 transferring movement of handle portion in the first plane of movement to axle member 902 to cause lifting and lowering of the connected cradle portion. The locating shaft 1203 of the second bearing set 906 providing location of the second bearing set 906 in the frame 505 is further illustrated.

Referring to Fig. 13A and 13B herein, a second embodiment of the stretching apparatus of the present invention is illustrated. In the second embodiment the cradle's second section 1306 which, in use, supports the subject's upper leg and thigh is indirectly connected to the cradle movement means 1301. Cradle movement means 1301 corresponds to the cradle movement means as described in respect of the first embodiment. The first and second embodiments differ in the mechanism by which each cradle is connected to the respective cradle movement

means. In the second embodiment, an L-shaped arm 1303 is positioned over the base member 1302 to connect to a supporting rod member 1304 which is connected to second cradle section 1306 by an adjustable bar member 1305. Second cradle section 1306 is further connected to a first cradle section for supporting the lower leg below the knee by hinge 1307 and latch member 1308.

L-shaped arm 1303 is connected to an axle member of the cradle movement means 1301 to transmit movement of the cradle movement means through a first plane of movement to the cradle to perform extension and flexion stretches. Operation of cradle movement means 1301 through a said first plane of movement swings arm 1303 through an arc indicated by arrow 1309. Arm 1303 is connected to rod member 1304 which transmits movement to cradle second section 1306 through adjustable bar member 1305.

Bar member 1305 is slideably mounted at one end either at the underside of rod member 1304 or within an internal cavity formed by rod member 1304. At a second end, bar member 1305 is securely fixed to the underside of cradle second section 1306. A spring mounted resilient plunger forms a clamp for positioning bar member 1305 in one of a plurality of optional preset positions providing for adjustment of the apparatus to accommodate subjects having different leg lengths. Rod member 1304 is mounted over the second bearing set as described in respect of the first embodiment which is in turn mounted in a frame (not shown) as described in respect of the first embodiment.

A locking means is further provided to retain arm 1303 in a central position over base member 1302 to isolate rotation of the cradle about the second bearing set from rotation about the first bearing set during performance of adduction or abduction stretching. The locking

mechanism comprises a spring loaded bolt member mounted on the underside of base member 1302 and arranged to be urged into locking position through corresponding apertures on base member 1302 and arm 1303. This prevents movement of the arm 1303 and attached cradle through the first plane of movement where rotation only about the second bearing set is required to perform the stretch. Use of this locking means allows for isolation of the cradle with respect to a selected plane of movement which enables stretching to be selectively performed through a specific plane of movement, thereby allowing for a stretch of a selected set of muscles.

The second embodiment provides an indirect connection between cradle and cradle movement means which enables the cradle movement means to be positioned outward from the position of the subject's hip relative to the arrangement of the first embodiment. This is advantageous as it prevents possible impingement of cradle movement means on the side of the subject's body during rotation about the second bearing set when leg abduction stretching is being performed. The use of L-shaped arm 1303 and rod and bar members 1304, 1305 also enable a stronger attachment to cradle movement means 1301. In the second embodiment the third cradle section is not required and is replaced by indirect attachment using arm 1303, rod member 1304 and adjustable bar 1305 for connection to cradle movement means 1301.

In a third embodiment of the present invention, the examination table and stretching apparatus are located approximately 15-30 cm from a ground surface. Support means is provided to support at least one cradle in a position of 0° flexion. The support means comprises a support leg, provided on the underside of one or both of the first cradle sections which extends substantially transverse to the main under surface of the first cradle section towards a ground surface, contacting the ground surface

and providing a support leg to support the subject's legs within the respective cradles. A roller or castor is provided at one end of the support leg configured to contact the ground surface. The support leg is provided in order to decrease the load on each of the ratchets of the cradle movement means which operate to maintain a selected position of each cradle through the first plane of movement. Each castor is configured to move across a ground surface such that abduction and adduction stretches can be performed wherein each castor rolls across the ground surface as the corresponding cradle and subject's leg are stretched.

Each castor is hingeably mounted at the underside of the respective first cradle section such that when the first cradle section is moved to a raised position, eg during flexion or lateral/medial rotation stretching the support leg hinges towards the underside of the cradle section into a storage position. As the cradle is lowered towards a position of 0° flexion the support leg automatically extends towards the ground surface to contact the ground surface and support the cradle.

In other respects, the third embodiment of the present invention is compatible with features of either or both the first and second embodiments of the present invention.

In a fourth embodiment of the present invention, the stretching apparatus is located above a support surface. Referring to Fig. 14A herein, there is illustrated an elevation view of the right hand limb cradle and chassis of the stretching apparatus in accordance with the fourth embodiment. The right hand limb cradle comprises a first cradle section 1401, a second cradle section 1402, and an arm 1403 that is connected to the second cradle section 1402. In the fourth embodiment the third cradle section is not required and is replaced by indirect attachment using arm 1403 for connection to the cradle movement means 1410.

The arm 1403 comprises at least one roller, castor or stub 1404 which extends substantially transverse to a main undersurface of the arm 1403 when the limb cradle is in a position of 0° flexion. The rollers, castors or stubs 1404 are in contact with a support surface 1405. This contact decreases the load on each of the ratchets of the cradle movement means 1410 which operates to maintain a selected position of each cradle through the first plain of movement. A height of the support surface 1405, and a height of the cradle movement means 1410, are adjustable relative to the chassis 1406 using adjustment means 1407. Furthermore, a distance of the chassis 1406 in relation to the examination table 1408 is adjustable using second adjustment means 1409. The first and second adjustment means allow for variations in a subject position or variations in a subject's anatomical dimensions.

When the limb cradle is in a position of 0° flexion, the rollers, castors, or stubs 1404 are in contact with the support surface 1405. It can be seen from Fig. 14B that the support surface 1405 is shaped to allow contact with the rollers, castors or stubs when abduction and adduction stretches are performed.

In other respects, the fourth embodiment of the present invention is compatible with features of any previous embodiment of the present invention.

In a fifth specific embodiment, the stretching apparatus is located above a support bar. Referring to Fig. 15A herein, there is illustrated schematically an elevation view of a right hand limb cradle and chassis of the stretching apparatus in accordance with the fifth embodiment. The right hand limb cradle comprises a first cradle section 1501, a second cradle section 1502, and an arm 1503 attached to the second cradle

section 1502. In the fifth embodiment the third cradle section is not required and is replaced by attachment using arm 1503 for connection to the cradle movement means 1507.

When the cradle is in a position of 0° flexion, the first cradle section 1501 is in contact at its lower surface with a support bar 1504. The support bar 1504 and the cradle movement means 1507 are located on a chassis 1505. A height of the support bar and a height of the cradle movement means are adjustable relative to the chassis using height adjustment means 1506. Furthermore, a distance of the chassis in relation to the examination table 1509 is adjustable using horizontal adjustment means 1508. The vertical and horizontal adjustment means may be used to compensate for variations in a subject's anatomical dimensions.

When performing abduction or adduction stretches, the cradle remains in a position of 0° flexion and therefore remains in contact with the support bar 1504 for at least an initial stage of the abduction or adduction stretch. To facilitate movement between the first cradle section 1501 and the support bar 1504, the support bar 1504 may comprise a low friction material, for example PTFE.

In other respects, the fifth embodiment is compatible with features of any of the previous embodiments of the present invention.

In a sixth embodiment, the first cradle section of the stretching apparatus is located above a support surface. Referring to Fig. 16A herein, there is illustrated an elevation view of the right hand limb cradle and chassis of the stretching apparatus in accordance with the sixth embodiment. The right hand limb cradle comprises a first cradle section 1601, a second cradle section 1602 and an arm 1603 forming indirect

attachment between the second cradle section 1602 and the cradle movement means 1610. In the sixth embodiment the third cradle section is not required and is replaced by indirect attachment using arm 1603 for connection to cradle movement means 1610.

A support arm 1604 comprising a stub or a castor 1605 is located on a lower surface of the first cradle section 1601. The stub or castor 1605 is in contact with a support surface 1606 when the right hand limb cradle is in a position of 0° flexion. A height of the support surface 1606 is adjustable relative to the chassis 1607 using adjustment means 1608. In addition, a height of the cradle movement means 1610 is adjustable relative to the chassis 1607 using a second height adjustment means 1609. A distance of the chassis 1607 relative to the examination table 1612 is adjustable using horizontal adjustment means 1611. These adjustments allow for variations in a subject's anatomical dimensions. Referring to Fig. 16B herein, it is shown that the support surface 1606 is shaped to allow contact between the support surface 1606 and the castor or stub 1605 when either cradle is used for abduction or adduction stretches.

In other respects, the sixth embodiment of the present invention is compatible with features of any of the previous embodiments.

To provide additional stabilization during use, each cradle can be locked in the central position, i.e. at 0° flexion/extension, 0° adduction/abduction, by use of an optional additional locking means acting on each bearing set whilst the other cradle is operated to stretch the subject's leg. The lock can be selectively activated to prevent movement about the first or second bearing set, both or neither

Further optional features of the stretching apparatus include a means for measuring the displacement of each cradle from the recognisable

central (neutral) position. An electrogoniometer can therefore be provided for analysis of the degree of stretch. Measuring the angle of stretch allows for quantitative orthopaedic assessment and monitoring of recovery from injury over time.

In further alternative arrangements the first cradle section supporting the lower half of the subject's leg, ie the calf and foot, is also adjustable in length and contains a foot-shaped support to support and limit movement of all or part of the respective foot.

In a further alternative arrangement, the examination table has a first end that is in close proximity to the stretching apparatus, and a second end in opposition to the first end. Cradle movement means are positioned at the first end of the examination table. A width of the first end is smaller than a width of the second end to allow room for the full movement of the handle of the cradle movement means.

The stretching device of the present invention may be made in separate male, female and children's versions by variation of the apparatus dimensions.

A mode of operation of the apparatus of the present invention, according to any of the embodiments described, for performing a variety of leg stretches will now be described. The stretching apparatus in accordance with Fig. 5 is initially located at an examination table. The examination table optionally comprises a pelvic clamp 304. The subject is positioned on the table in supine position, the subject's legs are placed in respective left hand and right hand limb cradles and the pelvic clamp and belt are placed in position to isolate movement of the lower limbs from the upper body. The subject's arms remain free during use of the apparatus and in a position so as to grasp the handle portions 506 to operate the

apparatus to perform various stretches. Once the subject has placed each leg in the respective cradle a strap is fastened over the upper and lower half of each leg extending from one wall portion of the respective cradle to the opposing wall portion and thereby encompassing the leg within the cradle. The subject can perform a stretching program as desired and may choose to stretch one or both legs at any one time. The following is an example stretching program in which all stretches begin from a resting position as illustrated in Fig. 1A, only one limb is stretched at a time:

Stretch 1 – Flexion

To perform flexion stretch of the left leg the subject pulls handle 506 of the left hand side cradle movement means towards the subject through an arc parallel to the wall portion of the third cradle portion 503. Flexion can occur for up to 120° from the resting normal position and the subject performs the flexion to an extent at which stretch is occurring and the subject is comfortable. The subject may then release the handle 506 wherein the stretch is maintained via the ratchet mechanism which allows the subject to fine control the stretch allowing small movements so as to bring the limb under stretch to a new position of tension by effectively taking up the slack in the leg as stretch occurs. For example, the subject can operate the handle 506 to move one step through the ratchet to achieve a further 4° rotation and further stretch. Again, the leg can be maintained by the locking ratchet in the new stretch position. This position can then be maintained by the subject for a pre-determined time length defined in the stretching schedule being implemented. When the subject decides to relax the leg, the ratchet is released through use of a catch or other control means at the handle or cradle movement means main body and the respective cradle is lowered from the flexion position to return to a resting position. This lowering movement occurs slowly via the damping mechanism within the control movement means.

Stretch 2 – Extension

Extension stretching is generally illustrated in Fig. 2. To achieve an optimal stretching position the non-stretching leg is placed in a raised and bent position as illustrated in Fig. 2. To move the non-stretching leg to the resting position the subject pulls the respective handle portion 506 through the first plane of movement to achieve an approximately 120° stretch as for flexion. The first cradle section 501 is rotated about hinge 507 such that the subject's knee bends such that the thigh and calf of the resting leg are at approximately 90°. This position is then maintained by the locking ratchet of the respective control movement means and supported by the respective leg cradle.

For a subject who exhibits tightness in the hip flexor muscles the thigh of the stretching leg will rise upwards to a position illustrated in Fig. 2. The stretching leg, which is retained in the cradle by means of straps, can be positioned in either two ways. One is achieved by rotating the first cradle section of the limb cradle housing the stretching leg about hinge 507 downwardly such that the first and second cradle portions 501 and 502 are positioned to house the thigh and calf of the stretching leg at approximately 90°. The other is to maintain the stretching leg in extended linear position as illustrated by the dashed lines in Fig. 2. The ratchet mechanism for maintaining the flexion position is then released, allowing the weight of the cradle and stretching leg to provide a downwards force to stretch the muscles on the front of the thigh. Additionally, the direction of the ratchet mechanism can be reversed such that by pushing on the handle 506 the subject can exert a downwards force on the cradle to augment the downwards force resulting from the weight of the cradle and stretching leg.

Stretch 3 - Medial and Lateral Rotation

The resting leg is maintained supported by a cradle in extended linear position. The stretching leg is raised through a first plane of movement using handle portion 506 and the second and third limb cradle sections are adjusted to be positioned at right angles so as to support the thigh and calf of the stretching leg at approximately 90° in raised position as illustrated in Fig. 1C. This raised position can be maintained by use of the locking ratchet of the respective cradle movement means. The subject is then in position to perform both medial and lateral rotation stretches about the hip joint. Medial rotation stretching is performed by the subject pushing on handle portion 506 to move the handle portion and cradle through a second plane of movement about second bearing set 906. To perform medial rotation stretching of the left leg this rotation will occur in a counter-clockwise direction about second bearing set 906. To perform lateral rotation stretching the subject operates handle portion 506 throughout the second plane of movement in a direction so as to move the stretching leg across the midline of the subject's body. For lateral rotation stretching of the left leg rotation occurs in a clockwise direction about bearing set 906.

Stretch 4 – Adduction and Abduction

In the resting position the subject operates handle portion 506 to rotate about second bearing set 906 to move a stretching leg either away from the body (abduction) or across the midline of the body (adduction) whilst maintaining the leg in the resting plane, i.e. substantially within the main plane of the subject's body. For abduction stretching of the left leg rotation of the cradle about second bearing set 906 occurs in counter clockwise direction. For performance of adduction stretching the resting leg is moved to a raised and bent position as described in respect of positioning the leg for medial and lateral rotation stretching such that the stretching leg can be moved across the midline of the subject's body without the resting leg interfering with the stretch. The resting leg is

supported in the raised and bent position by a respective cradle. For adduction stretching of the left leg rotation of the cradle occurs about second bearing set 906 in a clockwise direction.

The above descriptions of stretches are by way of example only, and are not intended to limit the ways in which the present invention may be practiced. For example, to perform the above stretches the subject need not be in the supine position, but may be in the anatomical position or in a position with the hips at substantially 90° flexion.

Where the subject is in the anatomical position, flexion stretches may be performed by operating the cradle movement means to move the cradle substantially in the sagittal plane.

Where the subject is in the anatomical position, abduction and adduction stretches may be performed by operating the cradle movement means to cause rotation of the cradle substantially in the coronal plane with respect to the subject.

Where the subject's hips are at substantially 90° flexion, abduction stretches may be performed by operating the cradle movement means to cause rotation of the cradle substantially in the transverse plane with respect to the subject.